



Mathematical and Physical Sciences Advisory Committee (MPS AC)

**F. Fleming Crim
Assistant Director
National Science Foundation
November 17-18, 2016**



High-Temperature Alloys → Jet Engines

A Journey in Materials Science

A Science Hors d'Oeuvre



Special thanks to John Schlueter, DMR



Mathematical and Physical Sciences

Materials in 787 Dreamliner GEnx Engine

A 60 Year Journey

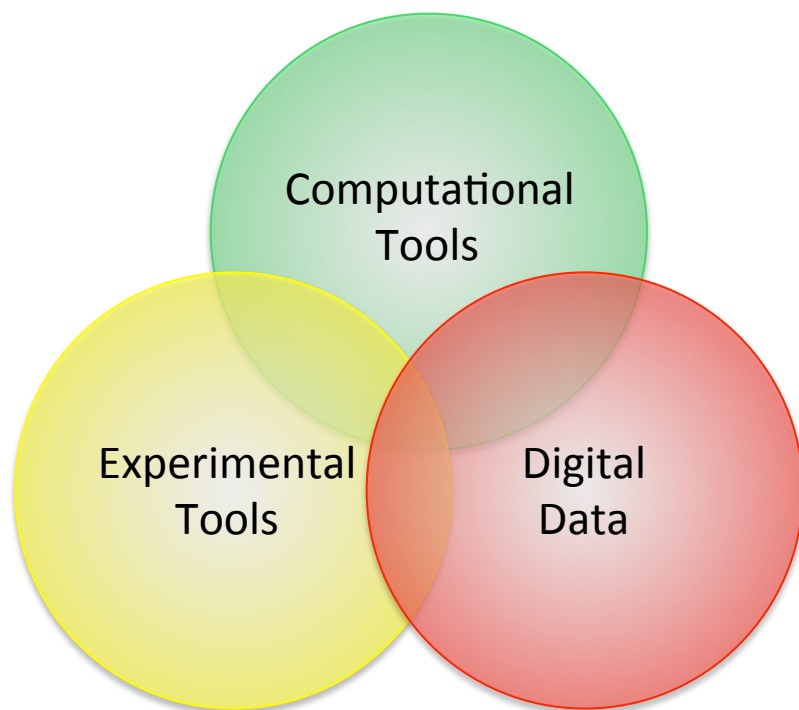


How to go faster ?

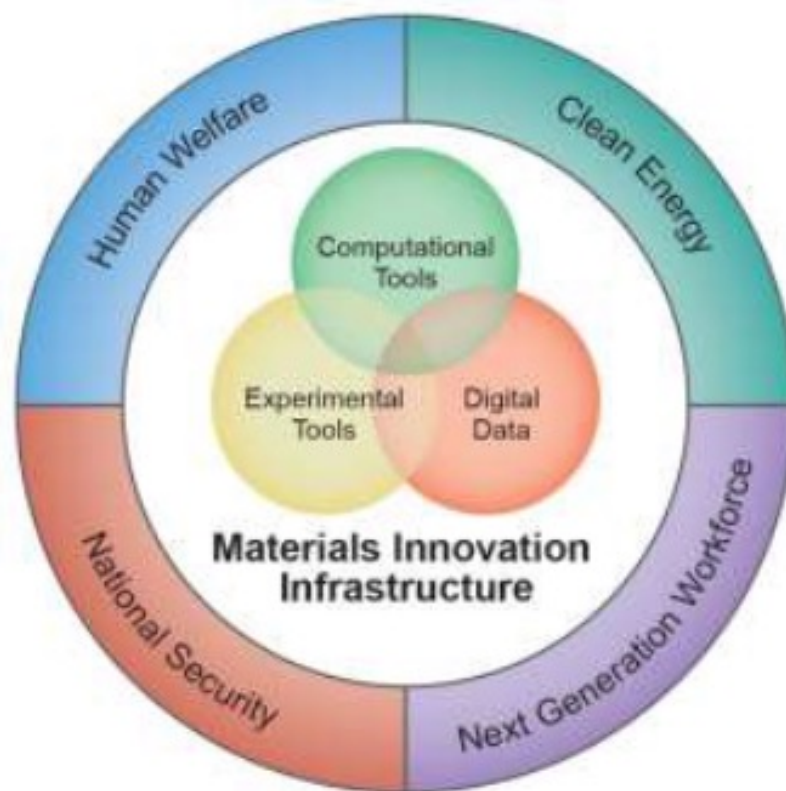


The Materials Genome Initiative (MGI)

Accelerating Materials Discovery,
Development, and Deployment Since 2011

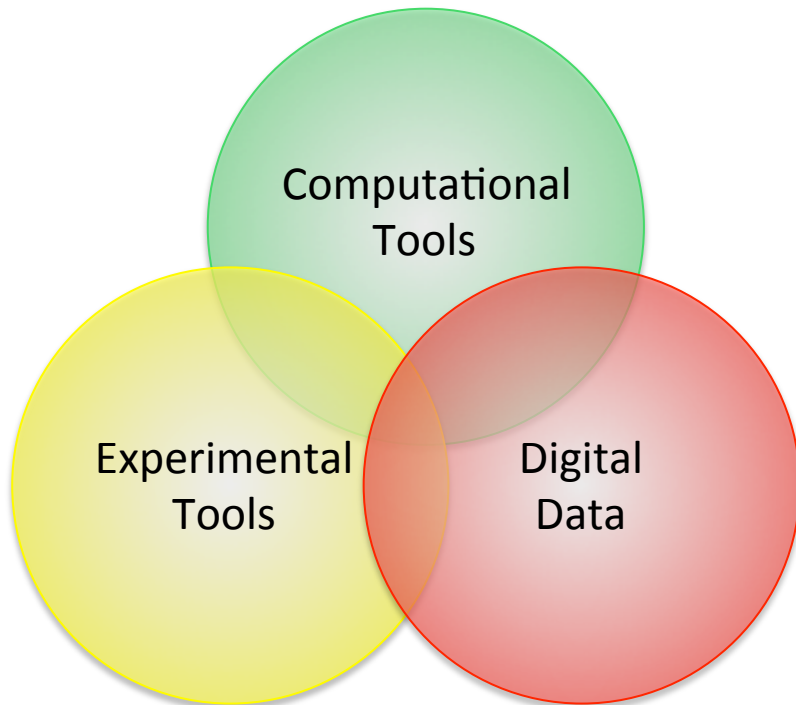


**Materials Innovation
Infrastructure**



The Materials Genome Initiative (MGI)

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**Materials Innovation
Infrastructure**

Goals

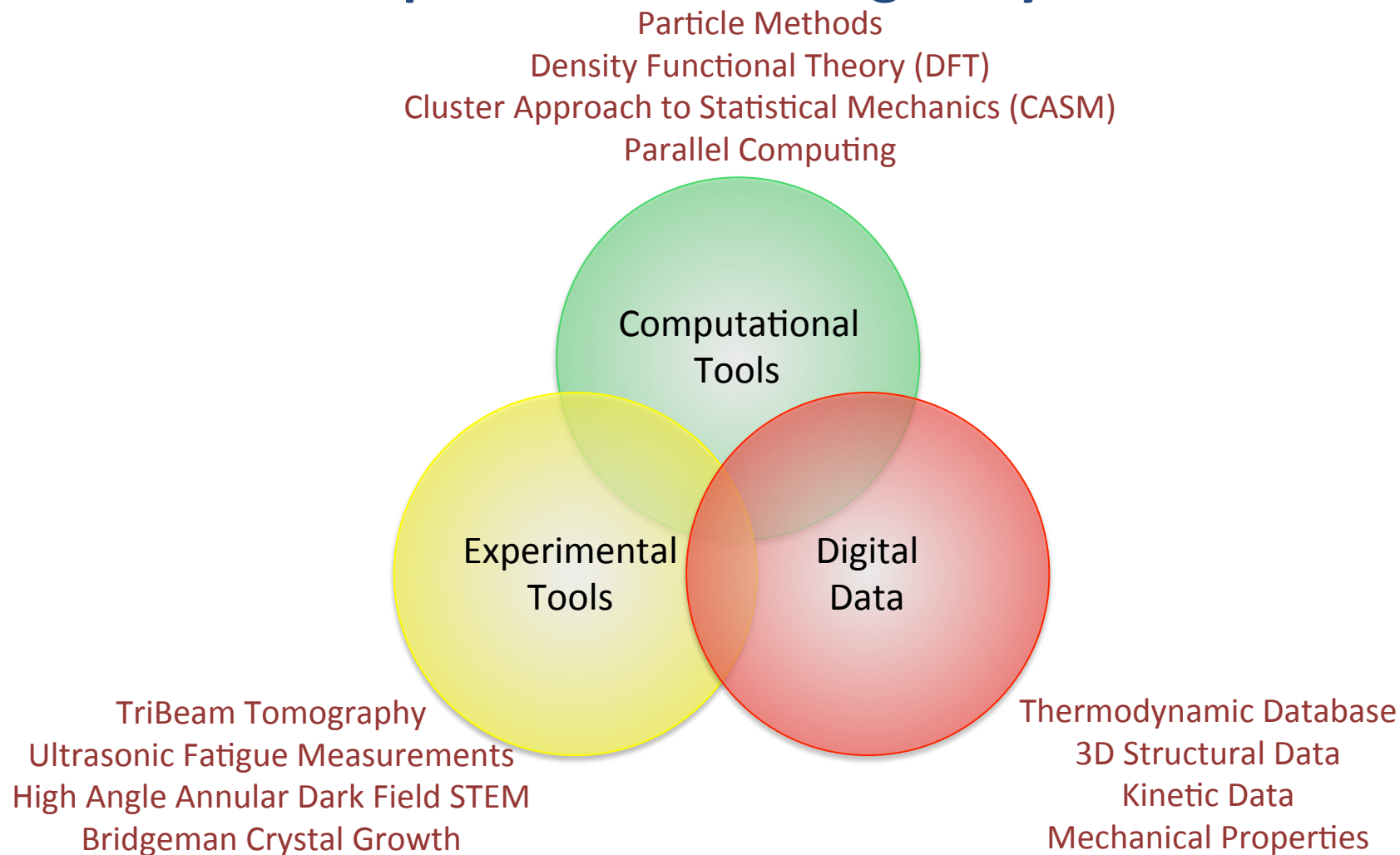
Integrated, team approach
Experiment, computation, theory
Digital data
Broadly trained workforce

NSF Programs

Designing Materials to Revolutionize
and Engineer our Future (DMREF)
Materials Innovation Platforms (MIPS)
Data Infrastructure Building Blocks (DIBBS)



An Example: Design and Synthesis of Multicomponent, Multiphase Metallic Single Crystals



An Example: Design and Synthesis of Multicomponent, Multiphase Metallic Single Crystals

Matt Begley (UCSB)
Mechanical Engineering, Materials



Frederic Gibou (UCSB)
Computer Science, Mathematics,
Mechanical Engineering



Anton Van der Ven
(UCSB)
Materials



Computational
Tools



Carlos Levi
(UCSB)
Materials



Tresa Pollock (UCSB)
Materials (PI)

Experimental
Tools

Digital
Data

Akane Suzuki (GE)
Materials, Industry



Gunther Eggeler (Bochum)
Materials, International



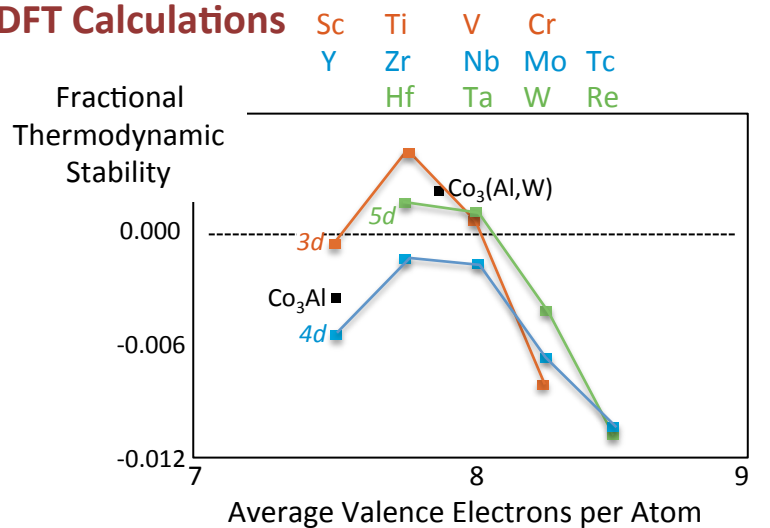
Mathematical and Physical Sciences



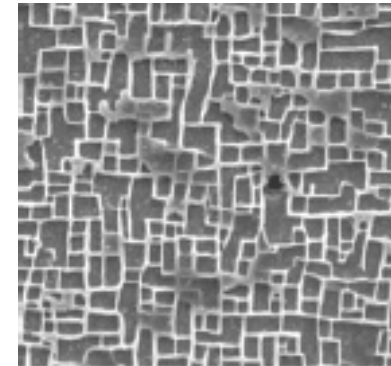
Calphad*-Assisted Discovery: L1₂ in Co-Al-W

*Computer Coupling of Phase Diagrams and Thermochemistry

DFT Calculations



Teresa Pollock, Nature Materials **15**, 809 (2016)



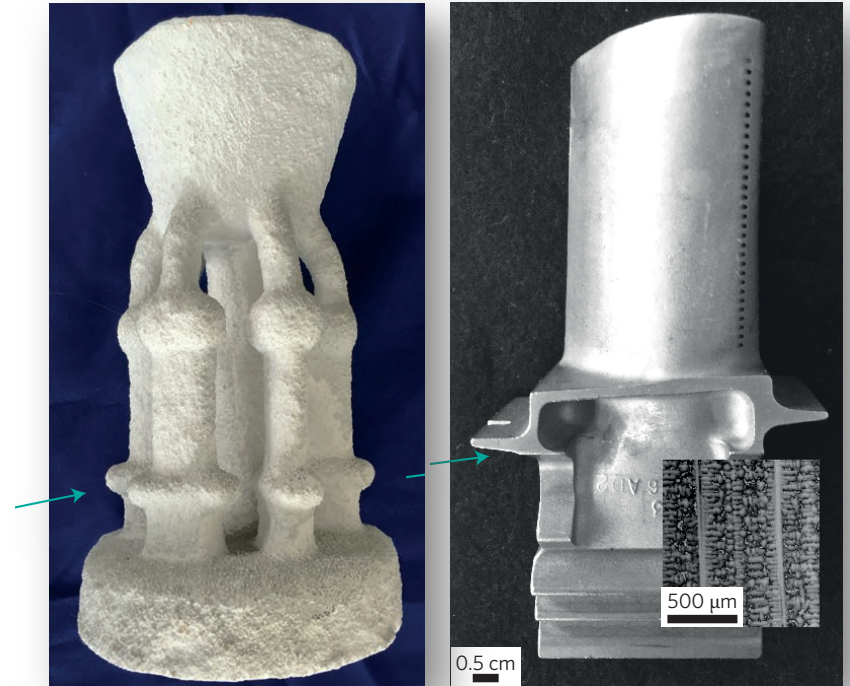
Co-Al-W-X

Goal: Explore the design space efficiently using theory and experiment

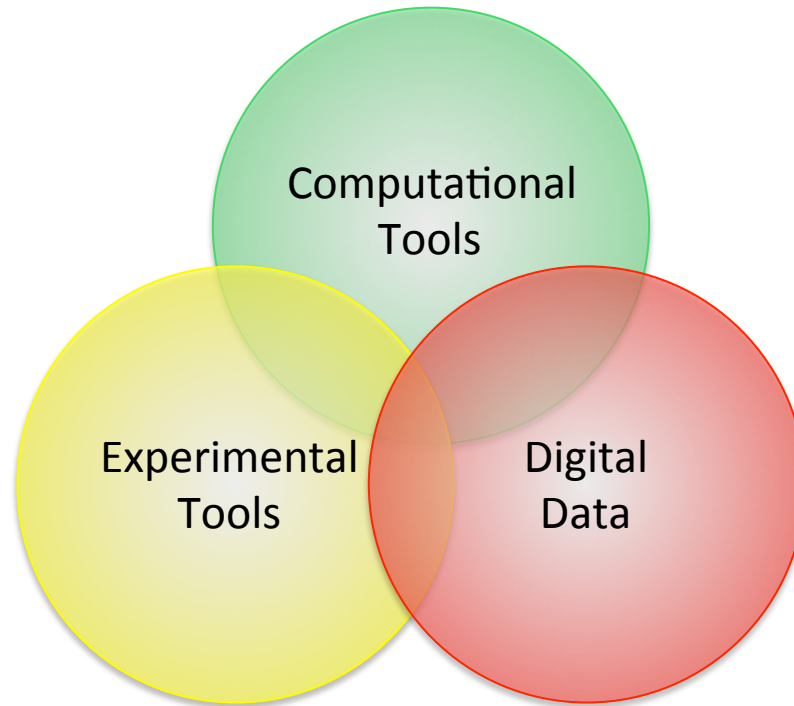
Synthesis

Combinatorial synthesis using
ion plasma deposition on substrate

15 cm single crystals
grown by Bridgman method



An Example: Design and Synthesis of Multicomponent, Multiphase Metallic Single Crystals



commentary

Alloy design for aircraft engines

Tresa M. Pollock

Nature Materials **15**, 809 (2016)



Mathematical and Physical Sciences

Science Nation Video from NSF



SCIENCE
NATION

<https://www.youtube.com/watch?v=deKomQdWd9Y>



Mathematical and Physical Sciences

Personnel
and
Plans

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Mathematical and Physical Sciences

Mathematical and Physical Sciences Advisory Committee

Farewell and Thanks



Bruce Elmegreen
IBM



Emery Brown
MIT



Susanne Brenner
LSU



Lynne Hillenbrand
CalTech

Welcome



Office of the Assistant Director

Farewell and Thanks



Sarah Dwyer
Science Assistant



Gloria Yancey
Directorate
Administrative
Coordinator
(Detailee from CHE)



Eduardo Misawa
Staff Associate
(Detailee from ENG)



Sue Hamm
Directorate
Operations Officer



Director
Geothermal Technologies
DOE



Office of the Assistant Director

Welcome



Tamara Savage
Science Assistant



Christopher Coox
Program Analyst



John Gillaspy
Staff Associate
(Detailee PHY)



Amanda May
Directorate Operations
Officer





Deborah Lockhart, DAD

Mathematical
and Physical
Sciences (MPS)

Office of
Multidisciplinary
Activities (OMA)



Clark Cooper

Astronomical
Sciences
(AST)



**Jim
Ulvestad
DD**

Chemistry
(CHE)



**Angela
Wilson
DD**

Materials
Research
(DMR)



**Linda
Sapochak
DD**

Mathematical
Sciences
(DMS)



**Michael
Vogelius
DD**

Physics
(PHY)



**Denise
Caldwell
DD**



Mathematical and Physical Sciences

Mathematical and Physical Sciences (MPS)

Astronomical
Sciences
(AST)



Chemistry
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Materials
Research
(DMR)



Mathematical
Sciences
(DMS)



Physics
(PHY)



Ralph Gaume
DDD



Carol Bessel
DDD



Sean Jones
Acting DDD



Tie Luo
DDD



Brad Keister
DDD



Mathematical and Physical Sciences

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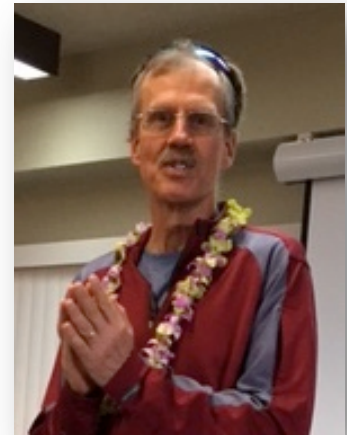


Jim Ulvestad

Search for AST Division Director Fall, 2017

Search Committee

Dr. Roger Blandford, Stanford University
Dr. Joel Bregman, University of Michigan
Dr. Debra Elmegreen, Vassar College
Dr. Lyman Page, Princeton University
Dr. Caty Pilachowski, Indiana University



<https://aas.org/posts/news/2016/11/recruitment-committee-nsfast-division-director-position>



Mathematical and Physical Sciences

MPS Advisory Committee

Quarterly Meetings

(2 at NSF, 0 – 2 Virtual)

Next Virtual Meeting
January 25, 2017
if needed

Next Meeting at NSF
April 6-7, 2017
Tentative !!



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Mathematical and Physical Sciences

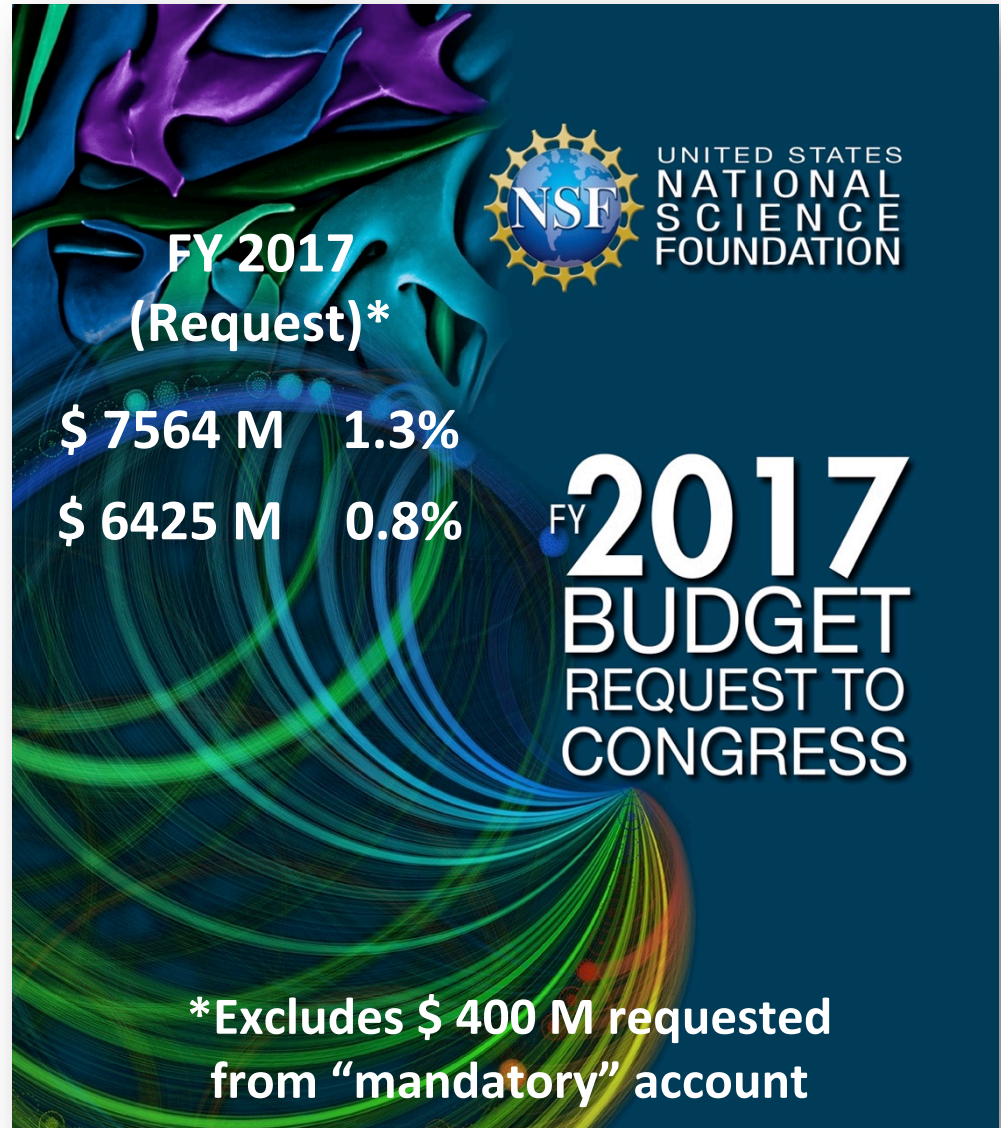
The President's Request and Congressional "Marks"

**FY 2016
(Estimate)**

NSF \$ 7463 M
R&RA \$ 6034 M

House Senate

NSF \$ 7406 M \$ 7510 M
R&RA \$ 6079 M \$ 6034 M



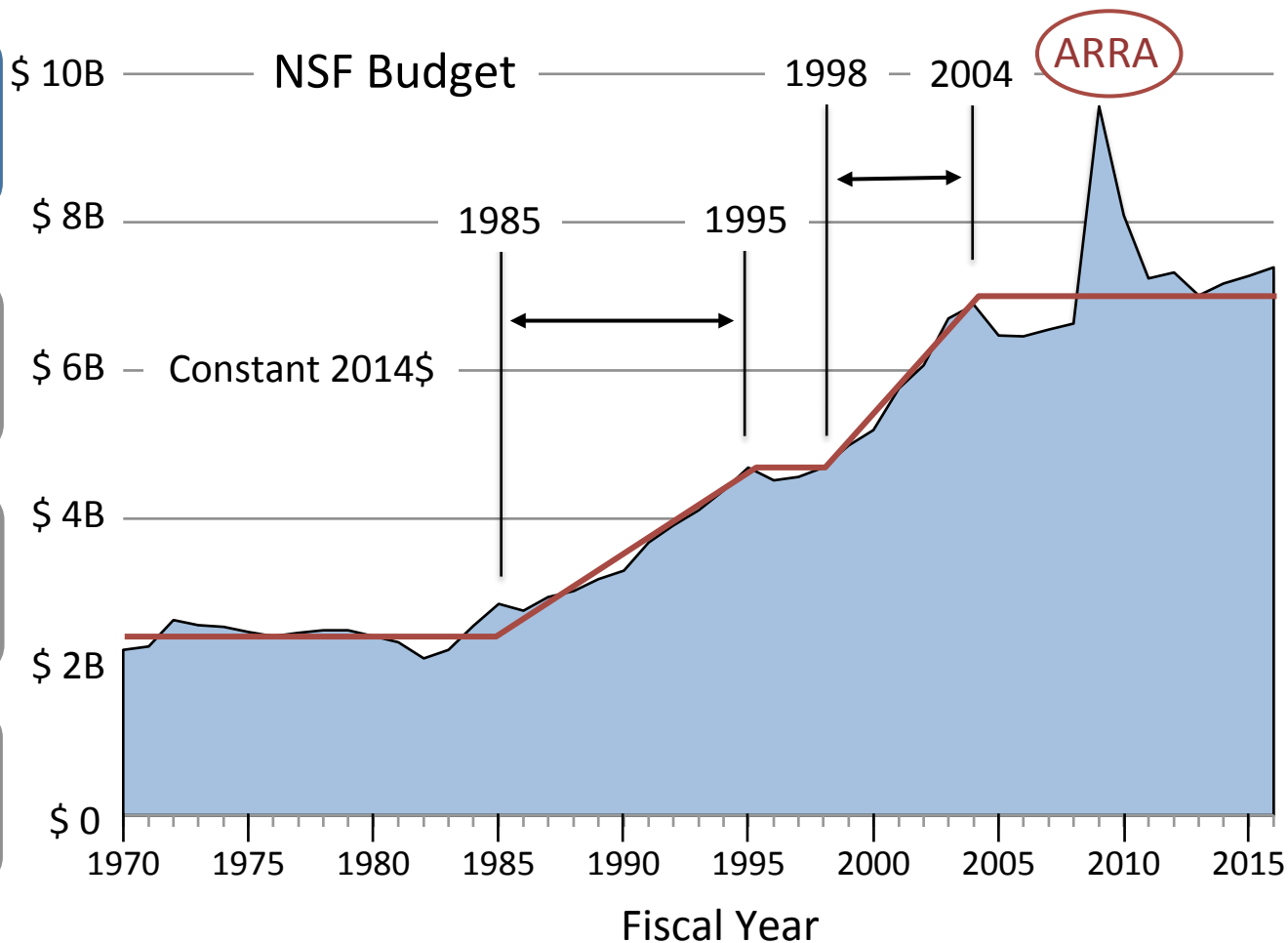
NSF by the Numbers FY 2016

NSF Budget
\$ 7.46 B

42 000
Research Proposals

12 000
Research Awards (22%)

140 000
Researchers



Mathematical and Physical Sciences

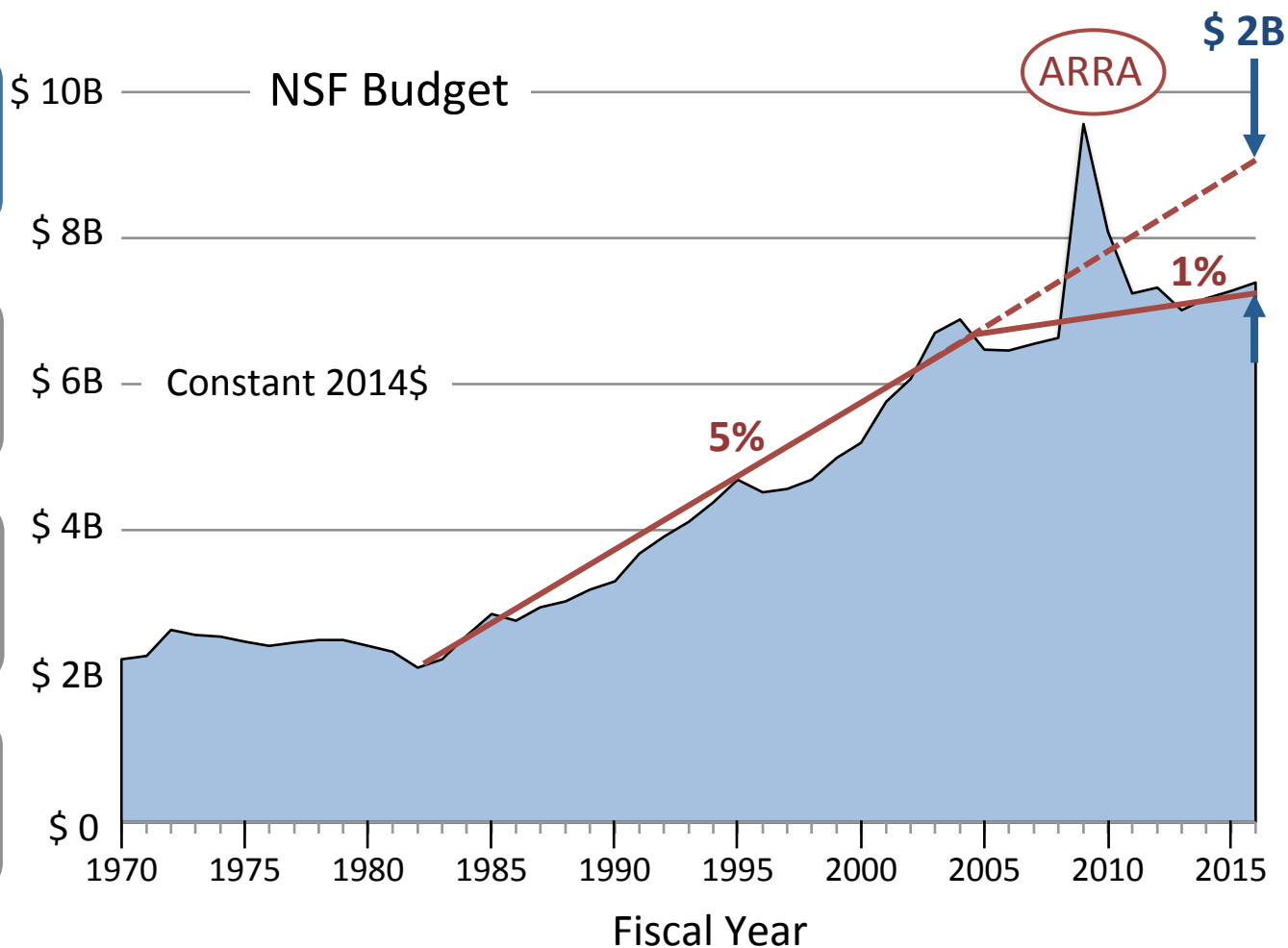
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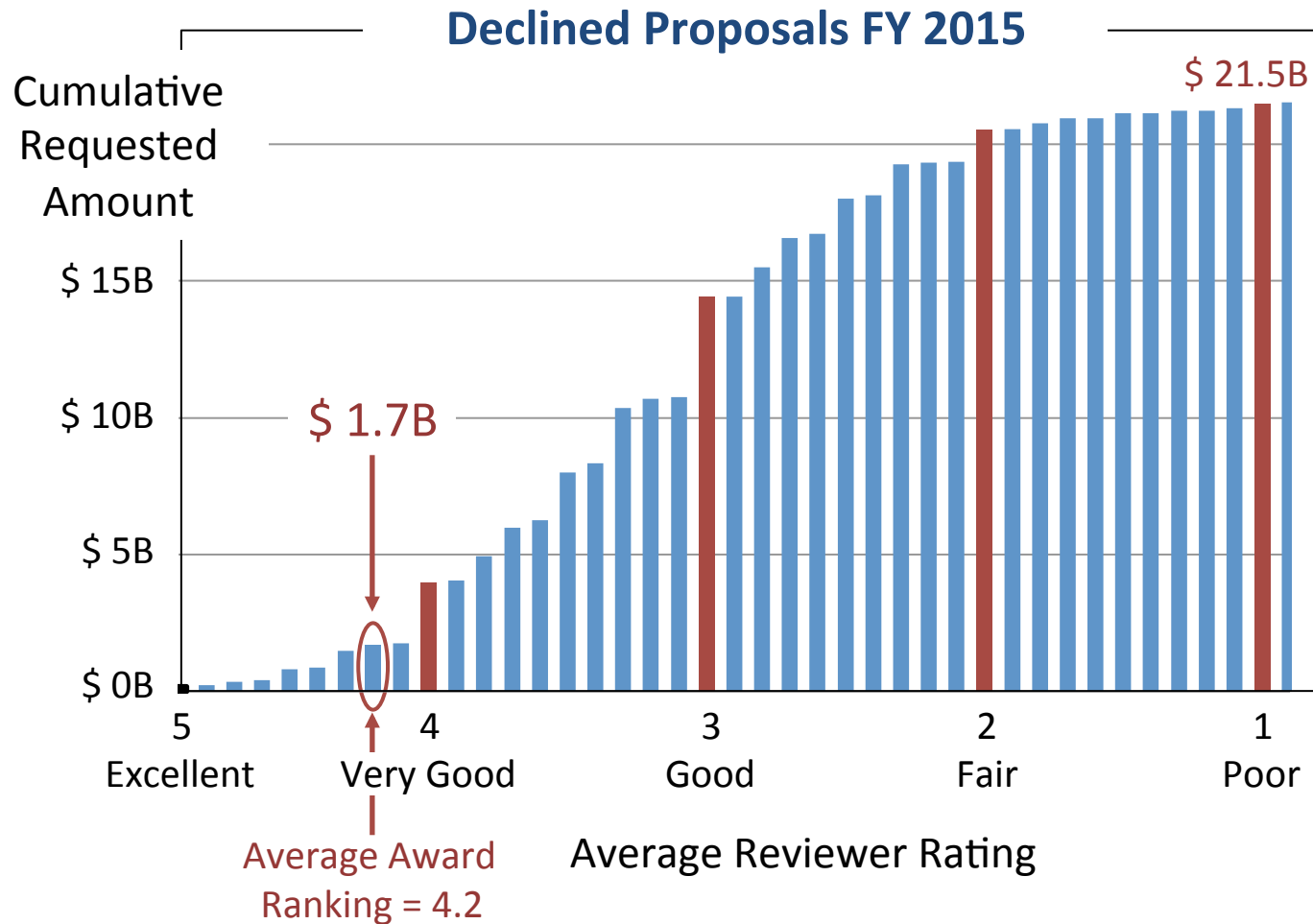
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Mathematical and Physical Sciences

Science Left on the Table



Report to the National Science Board on the National Science Foundation's Merit Review Process Fiscal Year 2015



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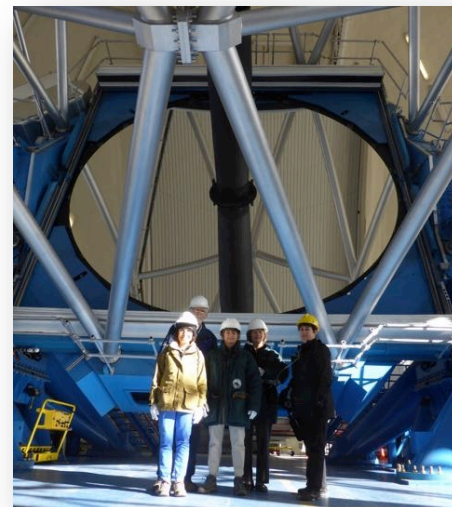
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Mathematical and Physical Sciences

NSB Members Visit to DKIST, VLBA, and Gemini



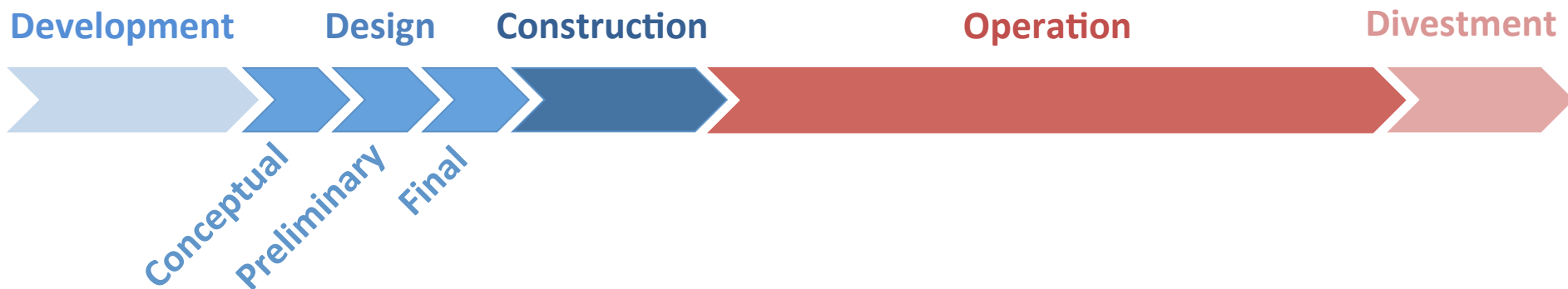
Mathematical and Physical Sciences

Progress on the High-Luminosity Large Hadron Collider (HL-LHC)



Transform detectors for
operation with intense beams
of the upgraded LHC

We are here



Mathematical and Physical Sciences



National High Magnetic Field Lab Sets New World Record



Strongest magnet (36 T) in the world
for NMR spectroscopy

Dramatically higher NMR sensitivity
for wider range of elements

Highest fields for chemistry and biology
- not just physics

Decade of planning, designing, and construction:
\$ 14.8M from DMR
mid-scale instrumentation program

Revolutionary technology:
Series connected hybrid magnet produces
stable and homogenous high fields



NSF says: Out with the old telescopes, in with the new

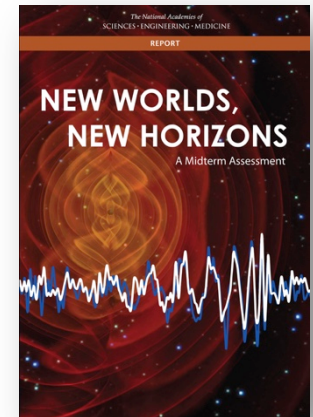
Agency wants to shed ownership of iconic radio dishes



Advancing Astronomy
in the Coming Decade:
Opportunities and Challenges

Report of the National Science Foundation
Division of Astronomical Sciences
Portfolio Review Committee

August 14, 2012



Telescopes for sale

The National Science Foundation (NSF) is trying to shed 10 aging telescopes to make way for new ones. So far, it has found partners for five of them, and \$12 million in savings.

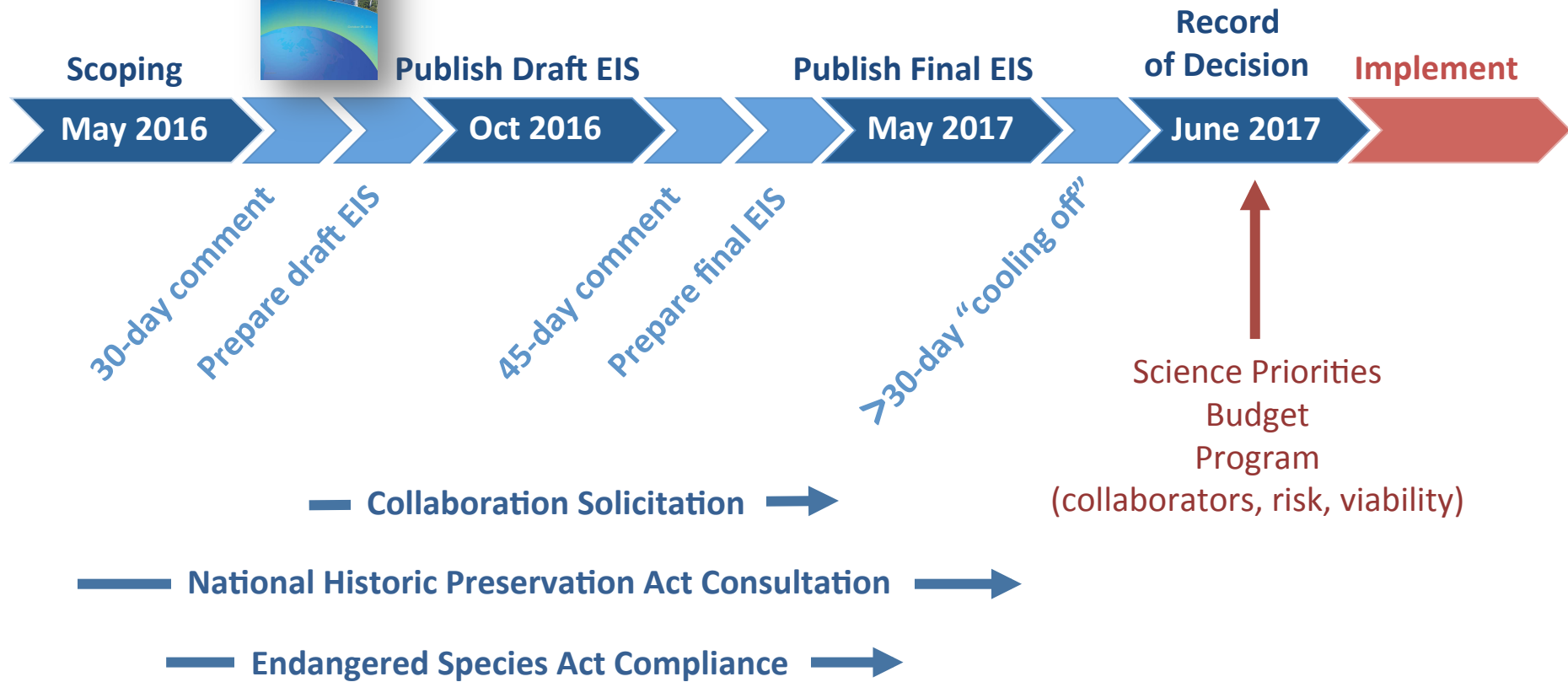
TELESCOPE ON OFFER	LOCATION	FIRST LIGHT	PARTNERS/STATUS	SAVING TO NSF
2.1-Meter Telescope	Kitt Peak in Arizona	1964	Caltech-led consortium	\$0.5 million
Mayall Telescope	Kitt Peak in Arizona	1973	Taken over by U.S. Department of Energy	\$4 million
Very Long Baseline Array	Various	1993	50% partnership with U.S. Navy	\$4 million
Green Bank Telescope	Green Bank, West Virginia	2000	Breakthrough Listen, NANOGrav, West Virginia University	\$2.5 million
SOLIS Telescope/GONG	Kitt Peak in Arizona	2003	NOAA sharing GONG operations costs	\$1 million
WIYN Telescope	Kitt Peak in Arizona	1994	NASA providing new exoplanet instrument	
Dunn Solar Telescope	Sacramento Peak in New Mexico	1969	University consortium in development	
Arecibo Observatory	Arecibo, Puerto Rico	1963	Environmental review in process	
SOAR Telescope	Cerro Pachón, Chile	2003	Status review when collaboration ends in 2020	
McMath-Pierce Solar Telescope	Kitt Peak in Arizona	1962	Small user community presents few partner opportunities	

Divestment Status (November, 2016)

Telescope	Status
KPNO 2.1m	Caltech-led consortium (Robo-AO) operating for FY 2016-2018.
Mayall 4m	Slated for DESI; bridge from NSF to DOE; NSF/DOE MOU for transition.
WIYN 3.5m	NOAO share to NASA-NSF Exoplanet Observational Research Program; NSF/NASA MOU in place; NASA instrument selected.
GBO	Separation from NRAO in FY 2017; ~25% collaboration for basic scope; started Environmental Impact Statement (EIS) process on October 19.
LBO/VLBA	Separation from NRAO in FY 2017; MOA with US Navy in place for 50%.
McMath-Pierce	No obvious partner opportunities; very small user community.
GONG/SOLIS	SOLIS is off Kitt Peak; GONG refurbishment; Interagency Agreement with NOAA signed (NOAA sharing GONG operations costs).
Sacramento Pk.	University consortium in development, and NSF funded NMSU for transition to consortium; started EIS process; completion in 2017.
Arecibo	Formal EIS process under way, and issuance of Record of Decision targeted for 2017. Draft EIS released October 28.
SOAR	Post-2020 status to be reviewed.

EIS underway or planned

Environmental Impact Statement Timeline (Arecibo as an Example)



Sacramento Peak and Green Bank are on similar paths
(2 - 6 months behind Arecibo)

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Mathematical and Physical Sciences

The Excitement of Advancing Discovery



Physics Nobel Laureates



Thouless

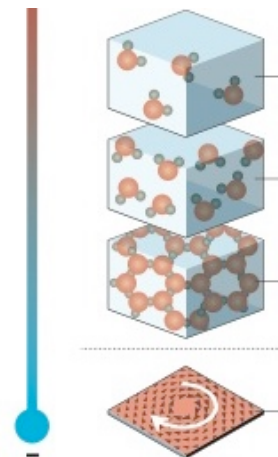


Haldane

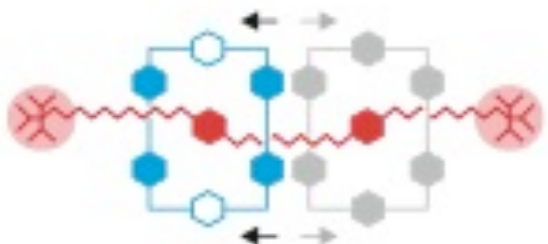


Kosterlitz

Topological Phases



Molecular Machines



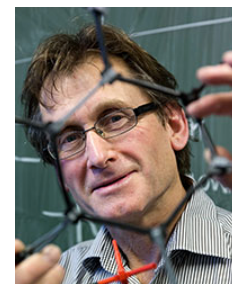
Chemistry Nobel Laureates



Sauvage



Stoddart



Feringa

A Sampling of Activities and Issues

Committees of Visitors

DMS COV

September 19-21 (report today)

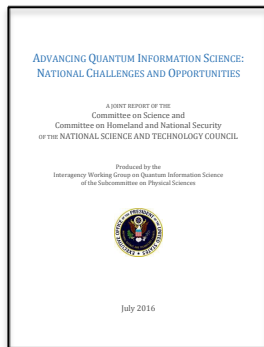


White House Events

National Strategic Computing Initiative First Anniversary

Strategic Options for Quantum Information

Materials Genome Initiative (MGI) Fifth Anniversary



Mathematical and Physical Sciences

A Sampling of Activities and Issues

Workshops, Meetings, and Reports

AST NAS Mid-decadal Report

CHE Workshops on Mid-scale Projects
(Centers, Instrument Development)

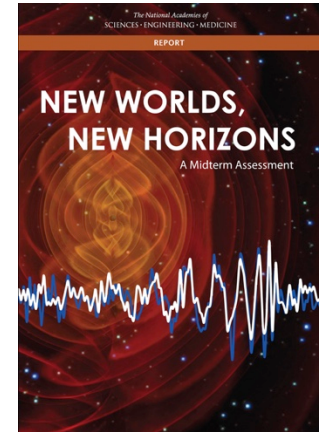
CHE Workshop on Quantum Information and
Computing for Chemistry

DMR Materials Research and Engineering Centers Directors

DMR Biomaterials Mid-scale Tools and Foundry Workshop

DMS Transdisciplinary Research in the Principles of Data Science (TRIPODS)
(joint with CISE/CCF following a workshop last summer)

PHY Connections in Quantum Information Science
(meta-program for MPS and beyond)



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Mathematical and Physical Sciences



Agenda – Day 1

State of the Directorate



Break

15

NSF “Big Ideas”

Fleming Crim (Assistant Director for MPS)
Juan DePablo (MPSAC Chair)

75

Working Lunch

60

NSF “Big Ideas” (Continued)

60

DMS COV Report

Peter Jones, Yale University (COV Chair)
Juan DePablo (MPSAC Chair)

60





Agenda – Day 1

Briefing on NSF Merit Review Process

Steve Meacham, Office of Integrative Activities

45

Break

15

Briefing on NSF Strategic Review Planning

Steve Meacham, Office of Integrative Activities

45

**Preparation for Meeting with NSF
Chief Operating Officer and
Head, Office of Legislative and Public Affairs**

45

Adjourn

Dinner at 7:30

Grand Cru





Agenda – Day 2

Robust and Reliable Science

Bogdan Mihailia and Clark Cooper
(Science Advisors, MPS/OAD)

60

Break

15

Meeting with NSF Chief Operating Officer

Richard Buckius (COO, NSF)
Amanda Greenwell (Head, OLPA)

60

General Comments and Discussion

60

Adjourn



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Image Credits

- Slide 3:
 - “The GENx Commercial Aircraft Engine.” General Electric Aviation. Web. 19 Dec 2016. <http://www.geaviation.com/commercial/engines/genx/>
 - “All Nippon Airways Boeing 787-8 Dreamliner JA801A OKJ in flight.” Wikimedia Commons. Web. 19 Dec 2016. https://commons.wikimedia.org/wiki/File:All_Nippon_Airways_Boeing_787-8_Dreamliner_JA801A_OKJ_in_flight.jpg
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 - “The Material Genome Initiative Strategic Plan.” National Science and Technology Council. Web. 27 Dec 2016. <https://www.whitehouse.gov/mgi>
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 - “Comic-tanium™: Materials Superheroes.” The Minerals, Metals, and Materials Society. Web. 19 Dec 2016. <http://www.tms.org/comictanium/league.aspx>
- Slide 8:
 - “Alloy design for aircraft engines.” Tresa M. Pollock, Nature Materials **15**, 809 (2016)



Image Credits (cont.)

- Slide 28:
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 - “Control Software of the CMS Experiment at CERN’s Large Hadron Collider.” MCRL2.org. Technische Universiteit Eindhoven. Web. 19 Dec 2016. http://www.mcrl2.org/web/user_manual/showcases/CMS.html
- Slide 29:
 - “National MagLab racks up new record with hybrid magnet.” National High Magnetic Field Laboratory. Web. 19 Dec 2016. <https://nationalmaglab.org/news-events/news/national-maglab-racks-up-another-record>
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 - “Jean-Pierre Sauvage - Facts”. Nobelprize.org. Nobel Media AB 2014. Web. 29 Nov 2016. http://www.nobelprize.org/nobel_prizes/chemistry/laureates/2016/sauvage-facts.html
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 - “Identifying Strategic Options for Advancing Quantum Information.” Whitehouse.gov blog. Web. 14 Dec 2016. <https://www.whitehouse.gov/blog/2016/10/18/identifying-strategic-options-advancing-quantum-information>
 - “The Materials Genome Initiative: The First Five Years.” Whitehouse.gov blog. Web. 14 Dec 2016. <https://www.whitehouse.gov/blog/2016/08/01/materials-genome-initiative-first-five-years>

